Report for 2004MN54B: Development of a Rapid Bioassessment Technique for Integrating Biological Data into TMDL Assessments in Urban Streams

- Articles in Refereed Scientific Journals:
    - None submitted to date. One manuscript in preparation for submission to Hydrobiologia and second ms in preparation for submission to Aquatic Insects. First deals with concepts to integrate new Chironomidae assessment protocol into TMDL evaluations. Second ms deals with community composition and longitudinal gradations of Chironomidae in an urban stream, Minnehaha Creek.
- Other Publications:
    - Leonard C. Ferrington Jr., 2004, Patterns of Chironomidae Community Structure in Hardwood Creek. Presentation to Technical Advisory Committee for TMDL assessment of Hardwood Creek. November 2004. Saint Paul, MN.
    - Leonard C. Ferrington Jr., 2005, Monitoring with Midges: Body size, bias and biomonitoring. Invited presentation at annual meeting, North American Benthological Society, May 2005. Susan E. Gresens and New Orleans, LA.

Report Follows

Development of a Rapid Bioassessment Technique for Integrating Biological Data into TMDL Assessments in Urban Streams

Principal investigators
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Research objectives
The goal of the project was to develop and refine a rapid bioassessment technique to generate biological data to be integrated into a current TMDL study of the Minnehaha Creek Watershed in Carver and Hennepin counties, Minnesota.

The original project was leveraged with two additional small grants that enabled the field work to be expanded to two additional urban streams in the Minneapolis/Saint Paul Metropolitan area that are also candidates for TMDL development--- Shingle Creek (Hennepin County, MN) and Hardwood Creek (Washington and Anoka counties). Shingle Creek is being investigated for elevated conductivity potentially resulting from road salt applications during winter and Hardwood Creek is being investigated for low dissolved Oxygen during summer.

In all three streams, EPA protocols for stressor identification have been employed to identify potential “stressors” that are contributing to patterns of Chironomidae community structure. Research objective 1 was to build a data base of empirical tolerances for each identified stressor for each chironomid species encountered in the three streams. Research objective 2 consists of developing conceptual models to predict changes in community structure that should occur if a variety of TMDL targets are met in the future. Research objective 3 is to develop a model of community composition that is characteristic of a “best attainable” water quality condition for local streams. The “best attainable” approach is similar to using a RIVPACS model to define a hypothetical community assemblage. I am using composition and phenology data for Chironomidae that have been generated for streams that are considered as regional reference candidates. Improving water quality conditions that are anticipated in the urban streams over the near-term future will provide for tests of the models’ accuracies, and will allow for fine-tuning or validation of them.

The protocols developed from this project will be tested independently in urban streams of Baltimore, Maryland. Based on results of the Baltimore study, the protocol can be fine tuned as a generalized method for generating biological data that can be integrated into TMDL assessments of urban streams in major metropolitan areas.

Methodology
In this project collections of surface floating pupal exuviae (SFPE) have been used to generate information about chironomid communities at an array of sites within the Minnehaha Creek, Shingle Creek and Hardwood Creek watersheds. This monitoring

technique is not well understood by water quality managers in the United States. Consequently, a detailed description of the technique in the following paragraphs.

Although not widely used in water quality investigations in the United States, collecting SFPE is not a new approach for gathering information about Chironomidae communities. It was first suggested by Thienemann (1910), but only occasionally used in taxonomic and biogeographic studies (Thienemann 1954, Brundin 1966) or ecological studies (Humphries 1938) until more recently. During the last 35 years, however, there has been increasing use of pupal exuviae collections in chironomid studies. Reiss (1968) and Lehmann (1971) used collections SFPE to supplement their larval collections when investigating Chironomidae community composition. In Western Europe and England collections of SFPE have been used extensively for surface water quality monitoring (McGill *et al.* 1979, Ruse 1995a, b; Ruse & Wilson 1984, Wilson 1977, 1980, 1987, 1989; Wilson & Bright 1973, Wilson & McGill 1977, Wilson & Wilson 1983). In North America the methodology has been successfully used in studies of phenology (Coffman 1973, Boerger 1981, Wartinbee & Coffman 1976), diel emergence patterns (Coffman 1974), ecology and community composition (Blackwood *et al*. 1995, Chou *et al*. 1999, Ferrington 1998, 2000, Ferrington *et al*. 1995, Kavanaugh 1988), microbial decomposition (Kavanaugh 1988), assessment of effects of point sources of enrichment (Coler 1984, Ferrington & Crisp 1989), non-point pesticide effects (Wright & Ferrington 1996), and effects of agricultural practices (Barton *et al*. 1995). In England and the United States SFPE collections have been used to study water and sediment quality (Ruse & Wilson 1984, Ruse *et al*. 2000, Ferrington 1993b), and used in Australia for measuring phenology (Hardwick *et al.* 1995) and effects of stream acidification on Chironomidae (Cranston *et al*. 1997). The following paragraphs briefly describe aspects of the methodology common to most of the above applications.

Chironomid larvae live in soft sediments or on rocks and interstitial materials in stream beds, where they generally attain densities of 1000 or more larvae per square meter in healthy stream systems (Coffman & Ferrington 1995), and often more than 30,000 larvae per square meter in organically enriched streams (Ferrington 1990). Upon completion of the larval life they attach themselves with silken secretions to the surrounding substrates and pupation occurs. When the developing adult matures the pupa frees itself from the silken chamber and swims to the surface of the water where the adult emerges from within the pupal skin (or exuvia). The exuvia fills with air and by virtue of an outer waxy layer of the cuticle (which has non-wettable properties) it remains floating on the water surface until bacteria begin to decompose the wax layer. Floating exuviae are concentrated by stream currents into eddy areas or into regions such as slack water areas downstream of rocks or points where riparian vegetation or fallen trees contact the water surface. By collecting exuviae from these "natural" collection points, one can rapidly evaluate the emergence of Chironomidae from a broad spectrum of microhabitats in the stream. Emergence frequencies are then calculated for all species in the SFPE sample.

Field collection of SFPE is accomplished by dipping an enameled pan into the water downstream of areas where pupal exuviae accumulate. Water, detritus and floating pupal exuviae flow in as one edge of the pan is dipped beneath the surface of the water. After the pan has filled with water, the contents are passed through a U.S. Standard Testing Sieve with aperture of 125 microns. Detritus and exuviae are retained by the sieve. The entire procedure of dipping and sieving is repeated until a large amount of detritus and exuviae is accumulated in the sieve. Contents of the sieve are then transferred to a sample jar and field preservative of 80% ethanol added, along with a sample label. Exuviae are sorted from detritus in the laboratory under 12X magnification to insure all specimens are found and removed. It has been my experience that 10 minutes of collecting provides sufficient sample size for impact assessments in streams moderately to severely impacted by organic enrichment in eastern Kansas, with samples often containing several hundred to a thousand or more exuviae. The SFPE protocol is accepted as a Standard Operating Procedure (SOP) and a Rapid Bioassessment Protocol for water quality investigations by Region VII of the U.S. Environmental Protection Agency (Ferrington 1987).

Principal findings and significance for the project

Field work in Minnehaha Creek for this study has focused on the lower watershed. Fourteen sample sites were selected that overlap the sites being used for the TMDL modeling. Site localities and the number of species detected are available on-line at: http://www.entomology.umn.edu/midge/minnehaha_sites.htm. Collections were made at approximately three-week intervals from early April through mid November, which spanned the greater portion of the ice-free period of the stream and encompassed the emergence periods of chironomids likely to occur in the creek. This design generated 182 samples. Based upon my past in urban streams (Ferrington and Crisp 1989, Ferrington 1990) I predicted that 40-45 genera, representing 80-95 species with a variety of tolerances to Phosphorus concentrations, sedimentation, and differing dissolved Oxygen concentrations, would be encountered in Minnehaha Creek. These estimates were exceeded and data has been collected for 124 species that have been detected in the stream. Several species are very small, with sizes less than 6 mm. These species are typically undetected or undersampled in monitoring and assessment activities (Figure 1), but comprise the most abundant size classes at most sample sites (Figure 2).

Figure 1: Differences in detection of larvae versus pupal exuviae as a function of size of species.

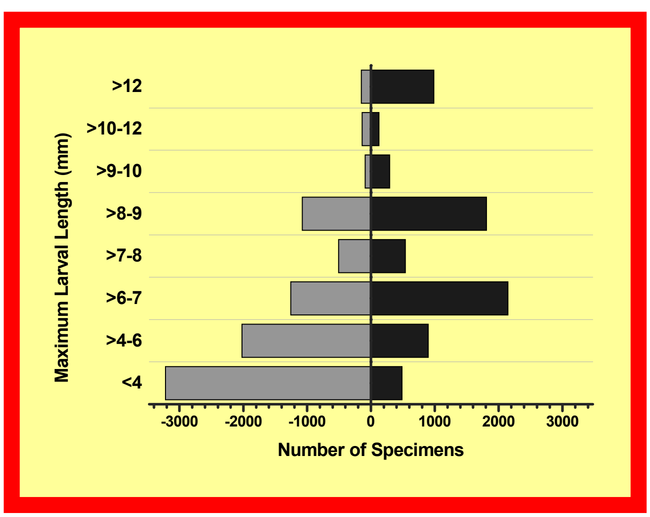
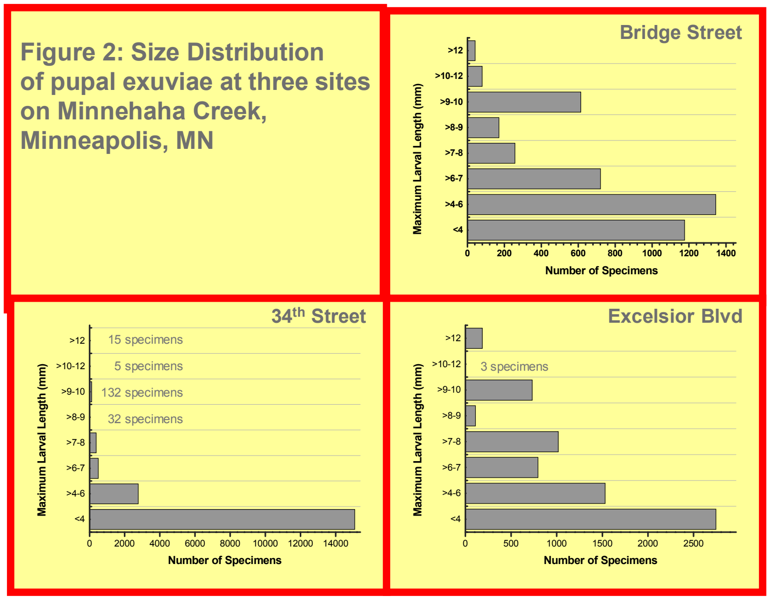
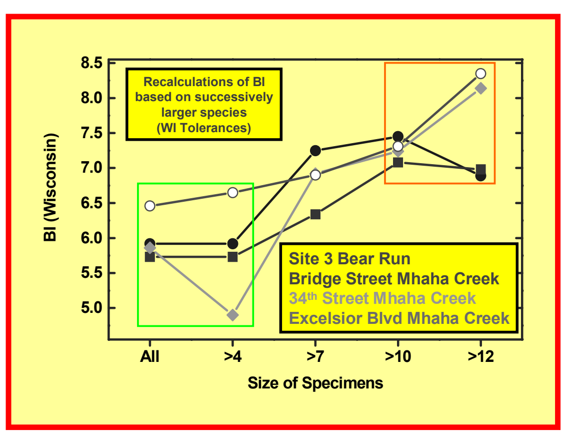


Figure 2: Size distribution of Chironomidae at three sites on Minnehaha Creek.



Undersampling smaller species can dramatically influence metrics that are calculated from biological data. The results of a series of simulations, in which smaller species are successively deleted when calculating biotic index values, are shown in Figure 3. These simulations demonstrate that calculated biotic index values increase when smaller species are deleted. Consequently, the metric indicates poorer conditions than actually occur.

Figure 3: Changes in biotic index calculations as smaller species are deleted. Data for one non-urban stream site, Site 3 Bear Run, are also shown to serve as a comparison with the urban sites on Minnehaha Creek.



Publications associated with this project or previous projects funded by NIWR/WRC – None submitted to date. One manuscript in preparation for submission to Hydrobiologia and second ms in preparation for submission to Aquatic Insects. First deals with concepts to integrate new Chironomidae assessment protocol into TMDL evaluations. Second ms deals with community composition and longitudinal gradations of Chironomidae in an urban stream, Minnehaha Creek.

Students supported by the project – Mr. Adam Sealock, Graduate Student in Water Resources Program, enrolled in MS degree program.